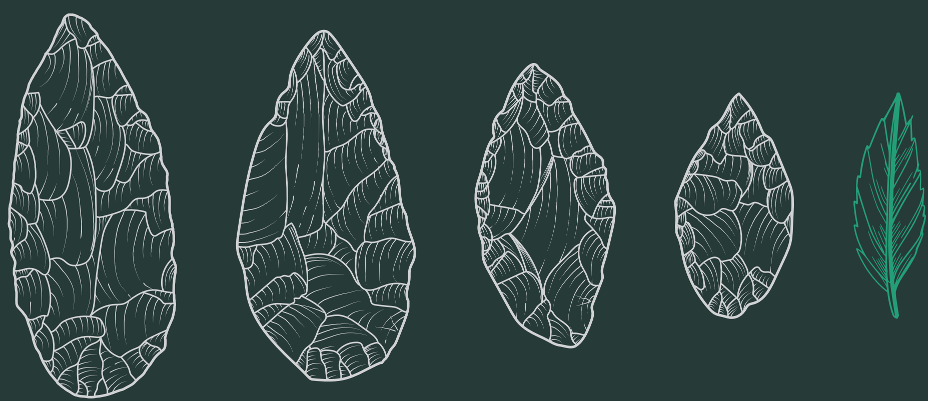
From tea leaves to leaf-shaped tools

STUDIES
IN HONOUR OF ZSOLT MESTER
ON HIS SIXTIETH BIRTHDAY



LITIKUM KÖNYVTÁR 2

EDITED BY
ATTILA KIRÁLY

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Editor:
Attila Király

ELTE
EÖTVÖS LORÁND
UNIVERSITY

LITHIC RESEARCH ROUNDTABLE

INSTITUTE OF ARCHAEOLOGICAL SCIENCES,
ELTE EÖTVÖS LORÁND UNIVERSITY,
BUDAPEST, HUNGARY,

2023

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LITIKUM KÖNYVTÁR 2 • LITIKUM BOOKS 2

Publisher:
Lithic Research Roundtable
Institute of Archaeological Sciences,
ELTE Eötvös Loránd University, Budapest, Hungary

Responsible publisher / Felelős kiadó:
Attila Király – editor, Litikum – Journal of the Lithic Research Roundtable
3524 Miskolc, Jósika M. u. 20. • attila@litikum.hu • https://litikum.hu

Responsible editor, series editor, layout editor:
Attila Király

ISBN 978-963-489-662-3 (PDF)
ISBN 978-963-489-661-6 (Softcover)
ISSN 2786-3751 (Online)

The volume was created in FR4 format using the fonts Source Sans Pro and Source Serif Pro, which fall under the SIL Open Font license. | The publication is available in *print-on-demand* form from the responsible publisher or from the Litikum editorial office.

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The provenance of a forgotten Copper Age spectacle spiral pendant

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Abstract. A spectacle spiral pendant, which has been known since the 1950s is kept in the Ferenc Kubinyi Museum in Szécsény. It was partially forgotten in the archaeological literature, or in other cases, it was duplicated. We discuss the possible provenance of its raw material and the place of its manufacturing based on the examination of the lead isotope ratios and chemical composition of the artefact.

According to the results, both could have been in the northwestern Carpathians, which falls within the distribution area of this pendant type. The exploitation of raw materials, the steps of manufacturing and the meaning of these artefacts represent local traditions and innovations, thus a completely independent metallurgical centre.

Keywords: Copper Age, Ludanice culture, Spectacle spiral pendant, Copper provenancing, Lead isotope analysis, Chemical compositional analysis

Cite as: Siklósi, Zs., Villa, I. M., & Nisi, S. (2023). The provenance of a forgotten Copper Age spectacle spiral pendant. In A. Király (Ed.), *From tea leaves to leaf-shaped tools. Studies in honour of Zsolt Mester on his sixtieth birthday* (pp. 297–311). Lithic Research Roundtable & Institute of Archaeological Sciences, ELTE Eötvös Loránd University, Budapest, Hungary. https://doi.org/10.23898/litikumsi02a14

1. Introduction

Large spectacle spiral pendants have been linked with the concept of the Copper Age since the 19th century. Ferenc Pulszky argued for the Copper Age to be an independent period based on the Stollhof hoard, which contained six spectacle spiral pendants alongside other artefacts (Pulszky, 1883; von Sacken, 1865). Although several similar pendants have been kept in museums since then (Fig. 1), and Irenäus Matuschik prepared their typological analysis (Matuschik, 1996), the available information about their former role, the manufacturing of these artefacts, and their provenance is scarce. A hoard was found at a Balaton-Lasinja settlement (at the site of Magyaregres-Varga-Bonyi-ároktól keletre) at the end of 2016, which was the first hoard containing such type of a pendant discovered during an archaeological excavation (Hornok & Kiss, 2017). As a consequence, the context of the deposition of the objects could also be studied.

Nándor Kalicz assumed an independent metallurgical centre within the area of the Ludanice-Jordanów/Jordansmühl-Balaton-Lasinja complex based on the distribution area of Stollhof-Csáford-type discs and spectacle spiral pendants (Kalicz, 1982, p. 13).

Although the context of the deposition of these objects and their former use were unknown, previous research has already linked them to a new metallurgical centre emerging in the northwestern Carpathians in present-day Slovakia (Dobeš, 1992; Krause, 2003; Matuschik, 1996, p. 29; Schreiner, 2007; Šikulova & Zápotocký, 2010). Although chemical compositional analyses were also carried out on several large spectacle spiral pendants (in addition to Balassagyarmat, also: Domahida/Domaneşti, Moravské Lieskové, Pohořelice, Rašovice, Stollhof, Štramberk-Kotouč (Dobeš *et al.*, 2019; Junghans *et al.*, 1968, pp. 31, 54; Šikulova & Zápotocký, 2010), the Magyaregres hoard was the first on which lead isotope measurements were also performed. According to the results, the provenance of the hoard's raw material is located in the northwestern Carpathians, and it could probably have been made in a workshop in this region (Siklósi *et al.*, 2022).

In 1950, Pál Patay inventoried the only other specimen from present-day Hungary into the Balassagyarmat museum collection (Fig. 2). Although P. Patay mentioned this object in his study about Copper Age metallurgy in 1958, he did not provide an illustration of it (Patay, 1958). Perhaps this is also the reason why the object appears incorrectly in later publications discussing spiral pendants. It is mentioned twice in I. Matuschik's catalogue of sites, first with no. 4. Balassagyarmat as a stray find, and then no. 5. from an unknown site in Hungary (Matuschik, 1996, pp. 31–32). In the case of the latter, I. Matuschik refers to Siegfried Junghans (Junghans *et al.*, 1974) and Konrad Spindler (Spindler, 1971, Fig. 5). However, the two objects are identical. This artefact was measured in the *Studien zu den Anfängen der Metallurgie* (SAM) project (lab. no. 6563, Junghans *et al.*, 1968, p. 182). The origin of the confusion might be the fact that P. Patay did not publish an illustration in 1958 and I. Matuschik probably did not find the object in the museum collection, so he could not identify that the two are the same.

Nothing is known about the circumstances of the discovery of another Malé Leváre type specimen from the Gbelce site (Furmánek, 1980; Matuschik, 1996; Récsey, 1892). We have not even found any evidence that the pendant was placed in a museum collection.

Large spectacle spiral pendants are known only from within the distribution area of the Ludanice-Jordanów/Jordansmühl-Balaton-Lasinja complex (Fig. 1). The only exception is the piece from the Domaneşti site, which, according to 19th-century description, was found as part of a Bronze Age hoard (Pulszky, 1883). Therefore, it is

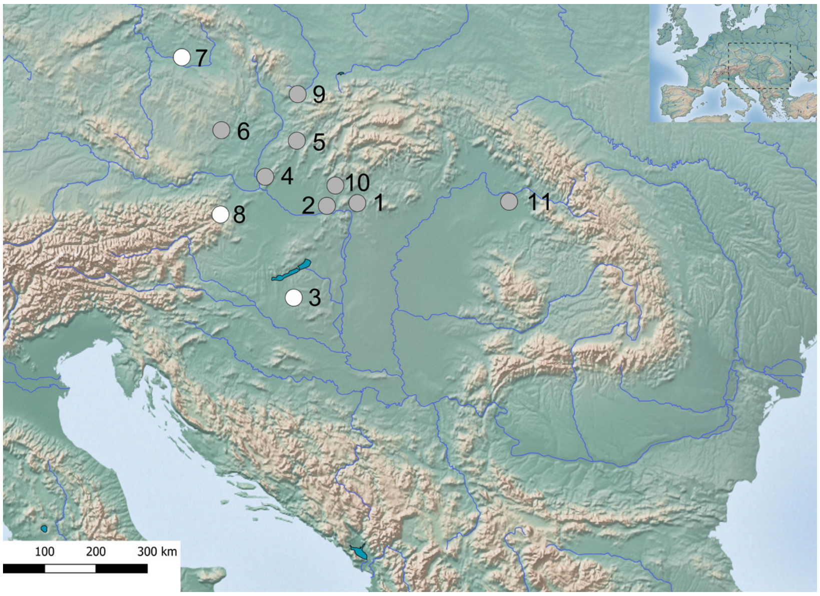


Figure 1. Sites of large spectacle spiral pendants. Marked in grey are the sites of the Malé Leváre type, made with a folded connecting section: 1. Balassagyarmat, 2. Gbelce, 3. Magyaregres-Varga-Bonyi ároktól keletre, 4. Malé Leváre, 5. Moravské Lieskové, 6. Pohořelice, 7. Rašovice, 8. Stollhof, 9. Štramberk-Kotouč, 10. Velky Pesek, 11. Domaneşti. Prepared by the authors.

uncertain whether this specimen could have originated in the region of present-day northwestern Romania and this area can also be considered the area of Copper Age use, or it is only the site of a much later deposition. Probably the latter is more likely. In the collection of the Hungarian National Museum, there are several objects from the Bronze Age hoard collected in Domaneşti in the Péchy collection, but none of them fit Pulszky's description. Identifying this pendant is difficult because according to Pulszky's description, one disc is broken into two pieces, the other wire is bent, and the drawing shows the reconstructed artefact (Pulszky, 1883, Fig. 5). Among Bronze Age and Early Iron Age metal artefacts from unknown sites, there is a large, fragmented spectacle spiral pendant, inv. no. 52.29.443, which is highly probably identical to the Domaneşti pendant. This was measured in the SAM project, lab.no. 12864-66 (Junghans *et al.*, 1968, p. 96).

Although the exact site and the circumstances of the discovery are unknown, we decided to carry out lead isotope and chemical compositional analyses on the Balassagyarmat pendant to compare it with the results of the Magyaregres hoard. Were they made of similar raw materials, of raw materials from the same or nearby mines?

2. Description of the find

The artefact is a spectacle spiral pendant (Fig. 2), broken into two pieces, which was wound from a copper wire of rounded cross-section. Its surface is heavily corroded, and covered with indentations caused by corrosion. During its restoration, it was vigorously cleaned, so it is now only covered by a thin, dark, matte oxide layer. A drilled hole can be seen on the larger piece. This is probably the location of the sampling done in the SAM project. The spirals have five threads. The end of the wire narrows gradually in the middle of the spiral and is pointed. The section between the two spirals is bent like a hook. The wire leading to the spiral on the right has thinned out in one place – probably due to corrosion – and broke. The pendant as a whole is slightly deformed, the spirals were probably forced to bend slightly out of their original position. Length: 19.5 cm and 9.3 cm, Width: 9.5 cm and 7.5 cm, diameter of spirals:

Figure 2. The large spectacle spiral pendant from Balassagyarmat. Photo by the authors.

7.7 cm. Inventory number: 50.633. Place of preservation: Hungarian National Museum, Ferenc Kubinyi Museum, Szécsény.

3. Methods

A 75 mg sample was taken with a 3 mm diameter stainless steel drill next to the previous sampling site. Prior to sampling, the sample site was first cleaned thoroughly removing all traces of corrosion. The sample was then extracted, documented and measured. A sample of 75 mg was acquired and sent to the laboratories for further investigation. After sampling, the object was restored.

3.1. Chemical compositional analysis

The concentrations of eighteen elements (Cr, Mn, Fe, Co, Ni, Zn, As, Se, Ag, Sn, Sb, Te, Au, Hg, Pb, Bi, Th, U) were measured by mean Inductively Coupled Plasma Mass Spectrometer (ICP-MS) model 7850 manufactured by Agilent Technologies (Santa Clara, California, USA) at the Laboratori Nazionali Gran Sasso, Assergi, Italy (Giuntini *et al.*, 2021).

The sample was weighed and dissolved in a sonic bath at 60 °C, using 10 ml of 10% solution of ultra-pure nitric acid purified with a sub-boiling system (DuoPur, Milestone, Bergamo Italy). After dilution, the sample was measured in quantitative mode introducing 4.0 ml min^{-1} of He in the collision cell of the spectrometer to minimise the potential risk of isobaric interferences due to polyatomic species generated by the plasma torch. All the operations related to the sample handling and the instrumental measurements were performed in an ISO6 clean room to avoid the risk of environmental contamination.

Table 1. Lead isotope abundance ratios of copper artefacts from Balassagyarmat and the hoard of Magyaregres.

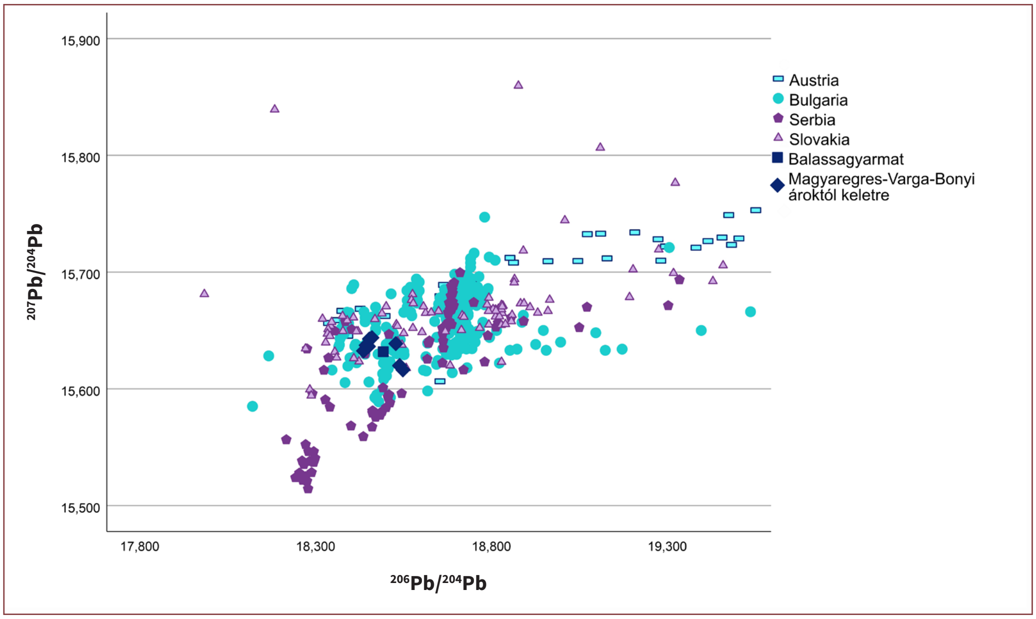
Site, Inventory number Artefact type	$^{206}Pb/^{204}Pb$	2 SE	$^{207}Pb/^{204}Pb$	2 SE	$^{208}Pb/^{204}Pb$	2 SE	$^{207}Pb/^{206}Pb$	2 SE	$^{208}Pb/^{206}Pb$	2 SE	Reference
Balassagyarmat, 50.633. Spectacle spiral pendant	18.4918	0.0177	15.6318	0.0143	38.3005	0.0426	0.84511	0.00011	2.07116	0.00022	-
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.22. Tubular spiral coil	18.4355	0.0038	15.6325	0.0031	38.5270	0.0076	0.84796	0.00004	2.08982	0.00007	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.33. Cylindrical bead	18.5476	0.0008	15.6162	0.0008	38.4973	0.0022	0.84195	0.00002	2.07560	0.00006	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.67. Tubular spiral coil	18.5379	0.0020	15.6198	0.0009	38.4954	0.0026	0.84259	0.00006	2.07652	0.00024	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.95. Tubular spiral coil	18.5383	0.0014	15.6200	0.0011	38.4989	0.0041	0.84261	0.00004	2.07679	0.00017	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.145. Spiral bracelet	18.4429	0.0026	15.6373	0.0022	38.5232	0.0054	0.84787	0.00002	2.08879	0.00005	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.182. Spectacle spiral pendant	18.4544	0.0011	15.6428	0.0010	38.5489	0.0026	0.84765	0.00001	2.08888	0.00005	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.183. Spectacle spiral pendant	18.4521	0.0035	15.6427	0.0030	38.5420	0.0127	0.84775	0.00004	2.08918	0.00008	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.243. Spiral bracelet	18.4496	0.0008	15.6363	0.0007	38.5315	0.0028	0.84752	0.00002	2.08844	0.00008	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.244. Spiral bracelet	18.4596	0.0016	15.6438	0.0012	38.5553	0.0032	0.84744	0.00003	2.08858	0.00009	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.253. Cylindrical bead	18.5274	0.0020	15.6387	0.0017	38.5131	0.0045	0.84406	0.00002	2.07866	0.00006	1

Reference: 1 = Siklósi *et al.*, 2022, table 2

Table 2. Trace element concentrations (in ppm) of copper objects from Balassagyarmat and the Magyaregres hoard.The concentrations were determined by ICP-MS with a relative measurement uncertainty of 5% for concentrations >1 ppm, rising to 20% for lower concentrations.

Site, Inventory number Artefact type	Co	Ni	Ag	Au	Sb	As	Bi	Pb	Ni/Co	Ag/Au	Bi/Sb	As/Sb	Ag/Sb	Reference
Balassagyarmat, 50.633. Spectacle spiral pendant	0.12	6	686	1.15	2628	0.51	160	0.60	51	598	0.06	0.0002	0.26	-
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.22. Tubular spiral coil	0.23	11	90	0.22	23	1.9	8.4	3.2	47.8	409	0.37	0.08	3.9	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.33. Cylindrical bead	0.72	22	23	0.23	1.7	0.26	2.7	23	30.6	100	1.59	0.16	13.5	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.67. Tubular spiral coil	0.14	23	541	0.14	3.3	2.4	1	16	164.3	3864	0.3	0.73	163.9	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.95. Tubular spiral coil	0.15	24	400	0.18	3.8	1.9	1.1	20	160	2222	0.29	0.5	105.3	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.145. Spiral bracelet	0.33	16	14	0.04	0.76	2.6	0.26	5.3	48.5	350	0.34	3.42	18.4	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.182. Spectacle spiral pendant	0.15	17	44	0.18	5.1	1.6	1.4	4.8	113.3	244	0.27	0.31	8.6	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.183. Spectacle spiral pendant	0.65	18	242	0.17	5.9	0.65	1.6	5.8	27.7	1424	0.27	0.11	41	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.243. Spiral bracelet	0.24	13	10	0.14	0.32	0.31	0.24	16	54.2	71	0.75	0.97	31.3	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.244. Spiral bracelet	0.35	16	14	0.02	0.74	0.31	0.26	4.9	45.7	700	0.35	0.42	18.9	1
Magyaregres-Varga-Bonyi ároktól keletre, Ő.2019.8.1.253. Cylindrical bead	0.27	22	163	0.12	0.62	0.36	0.16	7.7	81.5	1358	0.26	0.58	262.9	1

Reference: 1 = Siklósi *et al.*, 2022, table 2



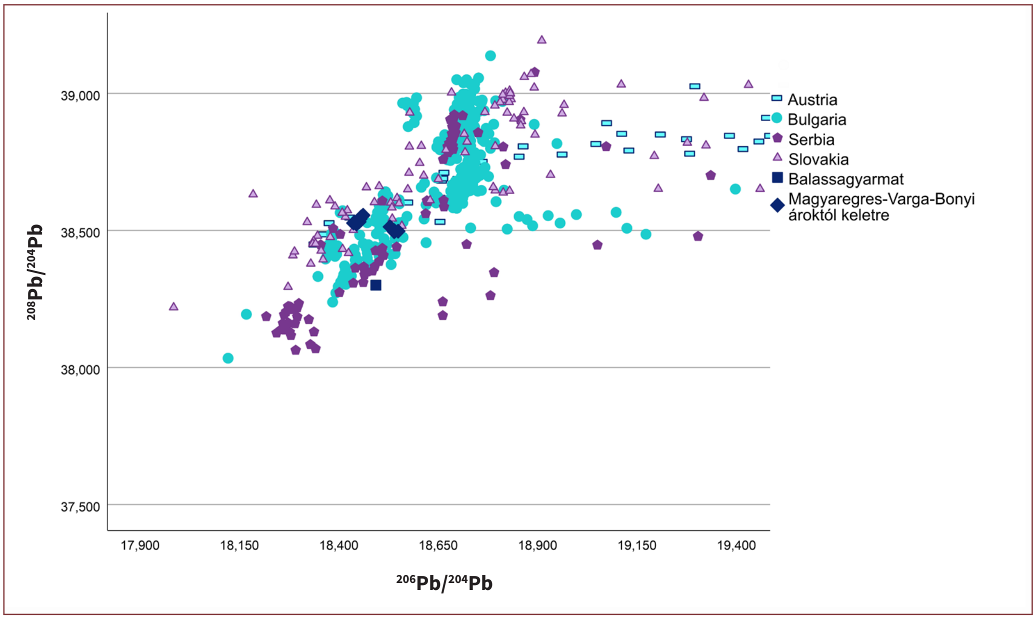


Figure 3. Potential sources of the copper raw material of copper finds from the Balassagyarmat pendant and the hoard Magyaregres based on lead isotope analysis. Bivariate plots are shown the measured lead isotope ratios, compared with the potential sources (Artioli *et al.*, 2016; Bugaj *et al.*, 2019; Gale *et al.*, 1991, 2000, 2003; Höppner *et al.*, 2005; Krauss *et al.*, 2020; Pernicka *et al.*, 1997; Pernicka *et al.*, 1993; Schreiner, 2007; Stos-Gale *et al.*, 1998) according to (top) ^{206}Pb/^{204}Pb vs ^{207}Pb/^{204}Pb and (bottom) ^{206}Pb/^{204}Pb vs ^{208}Pb/^{204}Pb. Prepared by the authors.

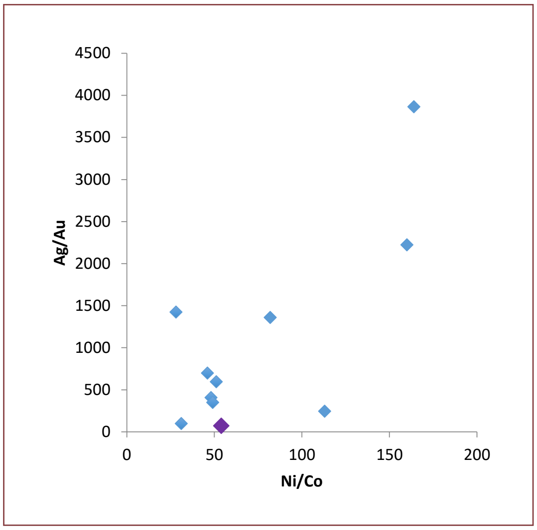


Figure 4. The silver/gold (Ag/Au) ratio versus the nickel/cobalt (Ni/Co) ratio. The Balassagyarmat pendant is marked by the purple diamond. Prepared by the authors.

The calibration of the instrument was performed by measuring five levels of concentration of reference solution containing certified amounts of the analysed elements.

3.2. Lead isotope analysis

To investigate the lead isotope ratios the drilled burrs (0.5–10.0 mg) were dissolved in hot triply distilled concentrated nitric acid in sealed PTFE vessels. As described in (Villa, 2009), the dissolved lead was purified using the SrSpec™ resin (EIChroM Industries) (Horwitz *et al.*, 1992). About 100 µl of resin is filled in a 3 mm diameter handmade PTFE column. The height-to-width ratio is approximately four. The sample solution is loaded in 0.5 ml 1M HNO_3, 1.5 ml of which is also used to wash out the matrix metals, while Pb is very strongly retained on the resin. Pb is then eluted with 1 ml 0.01 M HCl and is ready for analysis.

The measurements of lead isotope ratios were performed using a Thermo Scientific Neptune Multi-collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS) instrument at the Institute of Geology, University of Bern, Switzerland. This instrument is a dedicated tool for highly precise determination of lead isotope ratios, equipped with a double-focusing mass spectrometer of Nier-Johnson geometry. The Faraday collector array allows the simultaneous acquisition of masses 202 to 209. The sample introduction system consisted of an auto-aspirating low-flow (50 µl min^{-1}) Apex dissolving nebulizer (ESI Scientific, Omaha, NE, USA) mounted onto a combined cyclonic/double-pass spray chamber made of quartz glass. Potential isobaric interference of ^{204}Hg on ^{204}Pb was controlled and, if necessary, corrected by monitoring the ^{202}Hg signal. Hydride formation (PbH) was monitored on mass 209 and not detected. Mass fractionation was monitored by adding a small quantity of Tl, which has a known $^{203}Tl/^{205}Tl$ ratio, is fractionated by the same mechanism as Pb and does not interfere with Pb isotope measurements (White *et al.*, 2000). Typical in-run relative uncertainties (2 SE of the mean) on $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$ isotope ratios ranged between 0.004 and 0.020%. The measurement accuracy was controlled with frequent measurements of the NIST SRM 981 standard reference material interspersed with the sample measurements. The measured isotopic composition for SRM 981 was indistinguishable from the certified value and the recent, more precise literature measurements (Rehkämper & Mezger, 2000) so no adjustment of the measured ratios was necessary. The external reproducibility on the SRM 981 reference material over the measuring period of several days amounted to ±0.01% (2σ), very similar to the individual in-run precision on unknown samples.

4. Results

In the case of the ratio pairs $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$, as well as the ratio pairs $^{208}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$, we examined the agreement with the

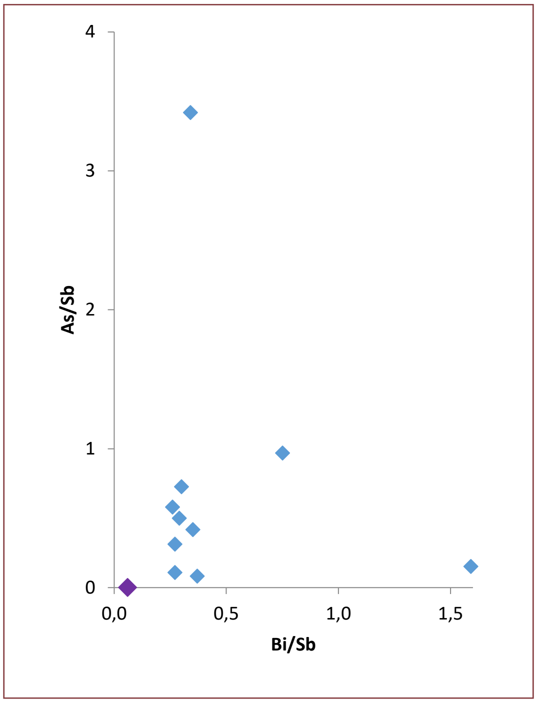


Figure 5. The bismuth/antimony (Bi/Sb) ratio versus the arsenic/antimony (As/Sb) ratio. The Balassagyarmat pendant is marked by the purple diamond. Prepared by the authors.

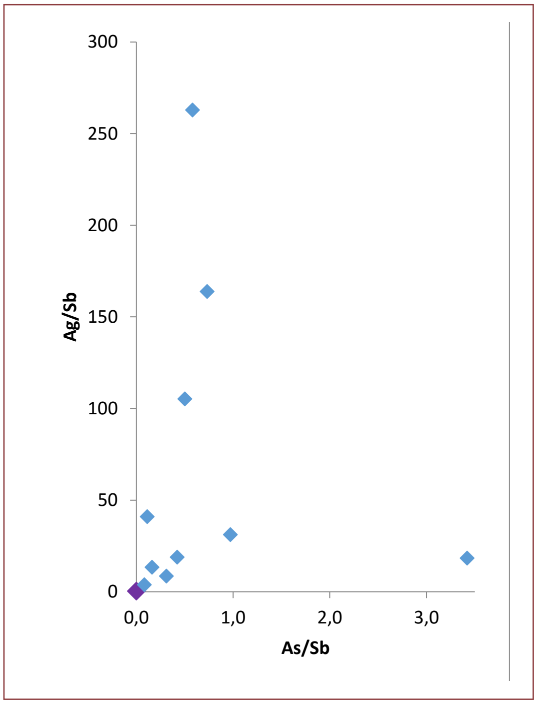


Figure 6. The silver/antimony (Ag/Sb) ratio versus the arsenic/antimony (As/Sb) ratio. The Balassagyarmat pendant is marked by the purple diamond. Prepared by the authors.

surrounding, published, geological sources to localize the source of the raw material (Artioli *et al.*, 2016; Bugaj *et al.*, 2019; Gale *et al.*, 1991, 2000, 2003; Höppner *et al.*, 2005; Krauss *et al.*, 2020; Pernicka *et al.*, 1997; Pernicka *et al.*, 1993; Schreiner, 2007; Stos-Gale *et al.*, 1998). In the case of the ratio pairs ^{207}Pb/^{204}Pb and ^{206}Pb/^{204}Pb, the raw material of the Balassagyarmat pendant corresponds to several possible, very broad fields of copper ore sources, including Bulgaria and northwestern Carpathians (Table 1; Fig. 3); the ^{208}Pb/^{204}Pb and ^{206}Pb/^{204}Pb ratio pair does not match any presently known and analysed copper ore source.

Based on the chemical element and trace element composition measurement, mainly Sb, Ag and Bi are found in smaller quantities in the Balassagyarmat pendant (Table 2). To reveal the geochemical regularities, we used the ratios of chemically related elements that could not be modified in prehistoric conditions and followed regularities derived from their chemical properties. We plotted silver/gold (Ag/Au) ratio versus nickel/cobalt (Ni/Co) ratio as they are refractory elements and remain unmodified during the *chaîne opératoire* (Fig. 4). The bismuth/antimony (Bi/Sb) ratio versus the arsenic/antimony (As/Sb) ratio plot shows the pnictogen elements that belong to a continuous series of highly variable As/Sb ratios (Fig. 5). The third plot shows the silver/antimony (Ag/Sb) ratio versus the arsenic/antimony (As/Sb) ratio (Fig. 6). As silver is refractory, arsenic is volatile and antimony is between them, their ratio provides information about the original chemical signature and the temperature on the object was worked (Bray & Pollard, 2012; Gross *et al.*, 2021; Siklósi *et al.*, 2022).

5. Discussion

The chemical composition of the spectacle spiral pendant from Balassagyarmat was already measured within the SAM project, and together with the Domaneşti pendant, it was classified in the C1B material group, which was considered to be common in the case of East-Central European Copper Age objects (Junghans *et al.*, 1968, pp. 31, 54). Since the SAM project, geochemistry has been applied also to metals deriving from ores, and the classification scheme based on absolute concentration thresholds has been superseded by actual geochemical systematics (Gross *et al.*, 2021; Villa, 2016).

The lead isotope ratios alone (Fig. 3) cannot localize the provenance of the raw material of the Balassagyarmat pendant with absolute certainty, so we tried to confirm the source area based on the chemical trace element composition.

By examining the ratios of the chemically related elements and comparing them with the Magyaregres hoard, we noticed a variability of the used raw materials. An important constraint is given by the Ag/Au and Ni/Co ratios, as Ni and Co could not be separated using pre-industrial know-how, and Au and Ag, if present in traces, were extremely unlikely to be intentionally modified during the *chaîne opératoire* and therefore reflect the original compositional signatures of the sources of raw materials. In a silver/gold (Ag/Au) versus nickel/cobalt (Ni/Co) plot (Fig. 4), the Balassagyarmat pendant forms a narrow group with some of the items from the Magyaregres hoard. This compositional similarity supported one of the interpretations of the Pb isotopic identification: the one which has shown that the Balassagyarmat pendant's raw material might derive from the northwestern Carpathians, as that of the Magyaregres hoard (Siklósi *et al.*, 2022).

Both the bismuth/antimony (Bi/Sb) ratio versus the arsenic/antimony (As/Sb) ratio plot (Fig. 5) and the silver/antimony (Ag/Sb) ratio versus the arsenic/antimony (As/Sb) ratio plot (Fig. 6) confirm the compositional proximity of the Balassagyarmat pendant to the Magyaregres hoard. The main difference lies in the extremely low As/Sb ratio of the pendant, which is a clear sign of the use of an As-poor, Sb-rich fahlore, which is very close to the pure tetrahedrite end-member. Other objects from the Magyaregres hoard derive from tetrahedrite with a higher tennantite component whereby each object has a slightly different As/Sb ratio (Figs. 5–6).

Based on the present data, it is likely that the raw material of the Balassagyarmat pendant comes from the area of the northwestern Carpathians. This is congruent with the archaeological data since similar, large spectacle spiral pendants are known only from the area of the Ludanice-Jordanów / Jordansmühl-Balaton-Lasinja complex (Fig. 1).

The next important question regarding the *chaîne opératoire* is where this pendant could have been manufactured. A distinctive feature of the design of the large spectacle spiral pendants is the shape of the element that connects the two discs. Specimens of the Malé Leváre-type pendants with a folded connecting section were found in an even narrower area of roughly 300 km in diameter, in the vicinity of the northwestern Carpathians. The research into the beginnings of copper mining in this region is not as intense as the research into the early copper mines in the Balkans, but the number of data that dates the exploitation of these resources from the Early Copper Age is increasing (Modarressi-Tehrani & Garner, 2014; Modarressi-Tehrani *et al.*, 2016; Schreiner, 2007). A recent study has already revealed traces of local copper metallurgy, e.g., in the Horná Mičiná site (Zachar *et al.*, in press). Thus, we can rightly assume that the workshop(s) where these pendants were made probably operated somewhere in the vicinity of this mining region, in present-day Western Slovakia. Although we still have little information about their location, the Transdanubia area still lacks traces of local metallurgy, even in those deposits where copper objects with a large demand for raw materials were found, such as Zalavár-Basasziget or Magyaregres-Varga-Bonyi-ároktól keletre. In the case of these Transdanubian sites, we concluded that these objects had already arrived here as finished products (M. Virág, 1986; Siklósi *et al.*, 2022).

In contrast to the Balassagyarmat pendant with a highly corroded surface, the artefacts from Magyaregres were preserved in such a good condition that we were able to reconstruct the individual steps of their manufacturing by examining them under a microscope. According to it, the pendants were wound up from thin copper sheets placed on top of each other, and the ends of the wire were thinned by hammering (Siklósi *et al.*, 2022). This production technology is not typical for Balkan objects, as the investigation of the production technology of the armbands found in the Durankulak cemetery showed that they were made by casting (Dimitrov, 2002). Thus, the procurement of raw materials, the steps of manufacture and the finished form can be linked to the local metallurgical centre.

Large spectacle spiral pendants are only known as part of hoard finds or stray finds from a narrower geographical area in present-day Hungary, Slovakia, Austria and the Czech Republic (Dohnal, 1973; Furmánek, 1980; Matuschik, 1996; Patay, 1958), no examples are known from burials. We hardly know anything about the circumstances of the discovery of these assemblages, they were mostly found scattered, by chance, in the 19th century or at the beginning of the 20th century (e.g., Stollhof, Štramberk-Kotouč, Malé Leváre, Rašovice) (Dobeš, 2013; Jisl, 1967; Matuschik, 1996; Novotná, 1955; Novotná & Novotný, 1974; Patay, 1958; Šikulova & Zápotocký, 2010), so it is very difficult to reconstruct who and how wore and used these objects.

In the burials in the area of the Ludanice-Jordanów / Jordansmühl-Balaton-Lasinja complex, only small copper items that require a small amount of raw material – beads, rings, small bracelets – are found. Only the stone stele found at the Sion site in Switzerland can provide a clue to the way how the large spectacle spiral pendants could have been worn. On this anthropomorphic stele, there is a depiction of a spectacle spiral pendant that is hanging from the neck accompanied by a dagger under the belt. Due to the latter and the lack of representation of female gender characteristics, it is interpreted as a male figure (Gallay, 1995). Because there are significant differences in space and time between the site of the stone stele and the distribution area of the large spectacle spiral pendants, we must be careful when applying this wearing representation directly to the East-Central European areas at the end of the 5th millennium cal BCE.

The large spectacle spiral pendants, as well as the large spiral bracelets, discs and pectorals that can be connected to them, represented exceptionally great value and wealth. The use of large spectacle spiral pendants was highly limited in space and time. It seems that they had meaning only within a narrow socio-cultural environment. As a consequence, we can consider them more a status good, a symbol of a social position, than a prestige good within this circle (Siklósi, 2004).

6. Summary

Every element of the large spectacle spiral pendant reflects the innovations of local metallurgy. In terms of culture, the Ludanice communities are the descendants of the earlier Late Neolithic Lengyel communities, who lived here for a long time and gradually acquainted and adapted to their environment. These communities laid the foundation for the development of local metallurgy by searching for local sources of raw materials. They recognized the characteristics of processing these raw materials and created their own object types. These objects were used only in a narrow circle, within the cultural complex where they were made. This is significantly different from several other types of objects of the same age, e.g., from the Jászladány axe-adzes, which were circulated in an extremely large area throughout Europe (Heeb, 2014). Consequently, these objects could have had a meaning that could only be interpreted within this circle, and access to them could have been severely limited.

Acknowledgements and statements

We are grateful to the Hungarian National Museum, Ferenc Kubinyi Museum, Szécsény, and especially to Szilvia Guba for the opportunity to examine the Balassagyarmat pendant. We thank Balázs Lencz, the restorer of the Hungarian National Museum, for sampling. We are grateful to Zsuzsa Hegedűs for her help in identifying the Domaneşti pendant and to Viktória Mozgai for measuring the weight of the sample.

Data availability statement. The authors confirm that the data supporting the findings of this study are available within the article.

Disclosure statement. No potential conflict of interest was reported by the authors.

Funding statement. The project is financed from the NRDI Fund (NKFI FK 124260, 'The spread of the products and technology of metallurgy in the Carpathian Basin between 5000 and 3000 BC' PI: Zsuzsanna Siklósi) by the National Research, Development and Innovation Office. The chemical compositional analysis was financed by the IPERION HS (TRENCH project).

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